

Crude Calculation of Pressure Spike from Underwater Photomultiplier Implosion

(Assumes 100% of the energy released during PMT implosion is converted to an outward-propagating spherical shock wave of pulse length equal to one phototube radius. The hydrostatic pressure in this shock wave is evaluated at the radius where it reaches the nearest-neighbor photomultiplier tube.)

DETECTOR PARAMETERS		IMB	BooNE	SuperK
Tube radius	m	0.064	0.10	0.25
Tube Spacing	m	1	0.6	0.8
Tube Depth	m	20	12	40

from Bill Foster's fading memory...

ENERGY RELEASE FROM PHOTOMULTIPLIER TUBE IMPLOSION

Water(Oil) Pressure ($\rho \cdot g \cdot h$)	Pa	196000	105840	392000
	Atm.	1.94	1.05	3.88
Tube Volume	m^3	0.0011	0.0042	0.0654
Implosion Energy Release	J	210	443	25656

= (water pressure)*(PMT volume)

PRESSURE IN SHOCK WAVE AS IT PASSES NEAREST-NEIGHBOR PHOTOMULTIPLIER TUBE

Shock Wave Radius	m	1	0.6	0.8
Shock Wave Length	m	0.06	0.10	0.25
Shock Wave Volume	m^3	0.80	0.45	2.01
Energy Density(total)	J/m^3	263	980	12760
Energy Density(compressive)	J/m^3	132	490	6380
Shock Wave Pressure	Nt/m^2	761294	1328157	5298388
	Atm.	7.5	13.2	52.5

radius of spherical shockwave as it passes neighbor tube

pulse length of shock wave (assume = tube radius)

volume of shockwave pulse as it passes neighbor PMT

total (kinetic + hydrostatic) energy density inside shock wave

hydrostatic energy density (=1/2 total)

compressive energy = $1/2 \cdot \text{vol} \cdot \text{Pressure}^2 / \text{modulus}$

?? IMB tubes failed tests at ~5 Atm.??

WATER/OIL DATA

Density of Water/Oil	kg/m^3	1000	900	1000
Bulk Modulus of Water/Oil	Nt/m^2	2.20E+09	1.80E+09	2.20E+09
Speed of sound	m/sec	1483.2	1414.2	1483.2

<http://www.quakerchem.com/solutions/brochures/quintolubric%20bro.1.pdf>

<http://230nsc1.phy-astr.gsu.edu/hbase/sound/souspe2.html#c1>